Passive Sampling Approaches for Contaminated Sediment Management

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with Kees Booij, Royal Netherlands Institute for Sea Research

Loretta Fernandez, US EPA- Narragansett

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Upal Ghosh, Univ. of Maryland Baltimore County

Steve Ells, EPA Office of Superfund Remediation and Technology Innovation

Superfund Sediment SSRC Resource Center

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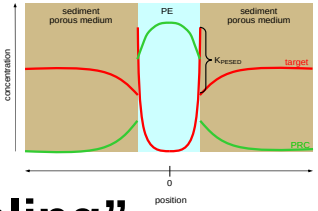
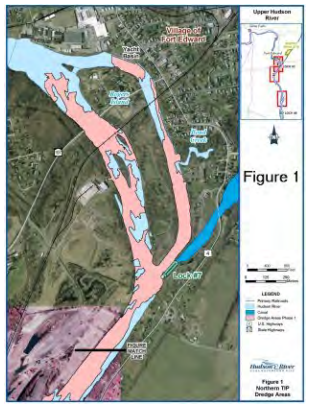
Passive Sampling Approaches for Contaminated Sediment Management

GOALS FOR TODAY'S SESSION:

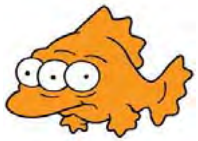


1. acquaint you with diverse methods we call "passive sampling"

2. convince you to say, "I could do that!"

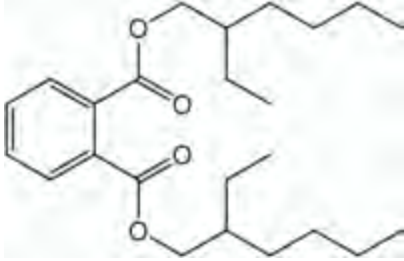


3. inform you so you can help site managers

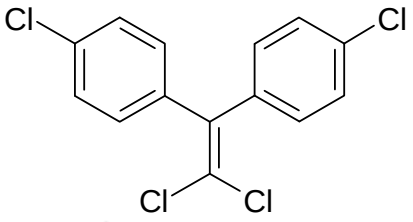


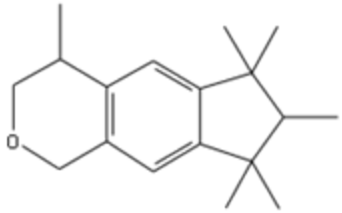
4. enable your use of passive sampling to:
   - assess sites (exposures)
   - gain info' needed to design remedial strategies
   - improve long term monitoring efforts

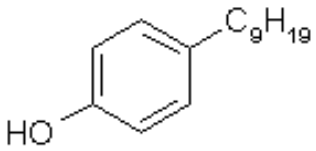
“The Problem”

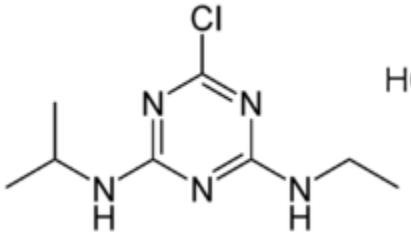


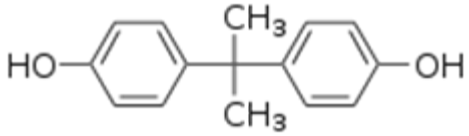
- have diverse array of organic chemicals in use
- many are persistent
- many are toxic
- many are “hydrophobic” => “sedimentophilic”

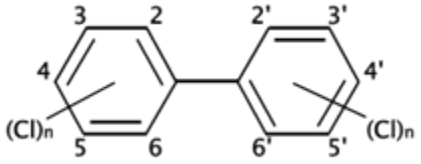


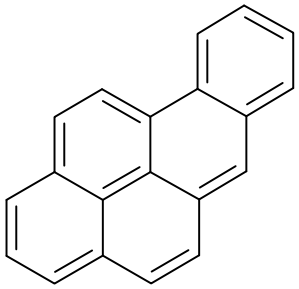


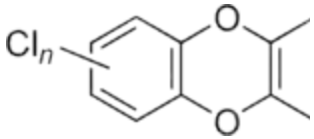


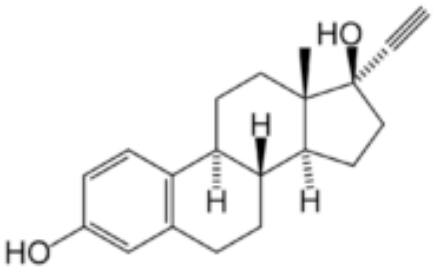


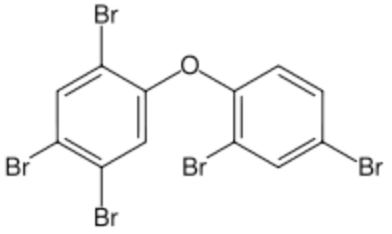










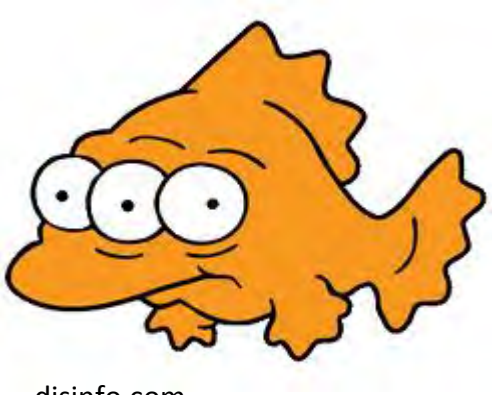


Many, many, many sediments contaminated & needing dredging

site (NAS, 2007)	Primary Chemicals of Concern	Volume of Dredged Sediment (cy)
Bayou Bonfouca, LA	PAHs	170,000
Lavaca Bay, TX	Hg	80,000
Black River, OH	PAHs	45,000-60,000
Outboard Marine Corp., Waukegan Harbor, IL	PCBs	38,000
Commencement Bay–Head of Hylebos, Tacoma, WA	PCBs, As, PAHs	419,000[c]
Duwamish Diagonal, Seattle, WA	PCBs	66,000
Puget Sound Naval Shipyard, Bremerton, WA	PCBs	225,000[e]
Harbor Island–Lockheed, Seattle, WA	PCBs, PAHs, Hg, Pb, As, Cu, Zn, tributyltin	70,000
Harbor Island–Todd, Seattle, WA	As, Pb, Zn, Cu, PAHs, PCBs, tributyltin, Hg	220,000
Cumberland Bay, NY	PCBs	195,000
Dupont, Christina River, DE	Zn, Pb, Cd	11,000
Lower Fox River (SMU 56/57), WI	PCBs	82,000
Ketchikan Pulp Company, Ward Cove, AK	4-methyl phenol; ammonia	8,700
Newport Naval Complex–McCallister Landfill, RI	PAHs, PCBs	34,000
GM Central Foundry, St. Lawrence River, NY	PCBs	14,000
Grasse River, NY remedial options pilot study (ROPS)	PCBs	30,000
Lake Jarnsjon, Sweden	PCBs	196,000[g]

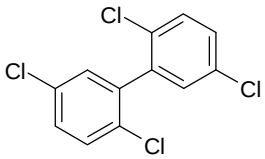
and many more off the page…

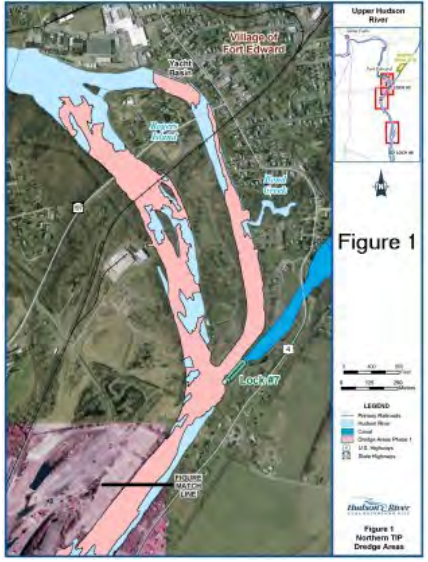
Problem: where are the beds hazardous?



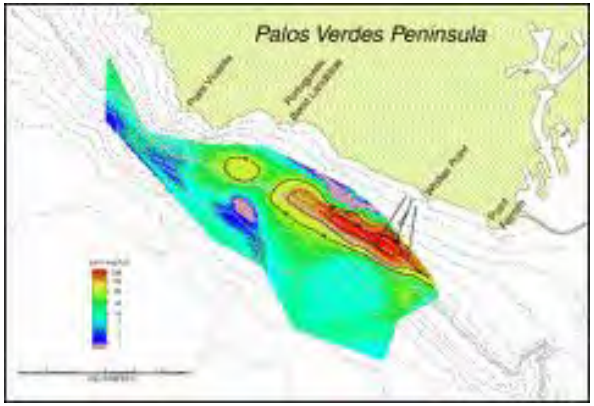
disinfo.com

en.wikipedia.org

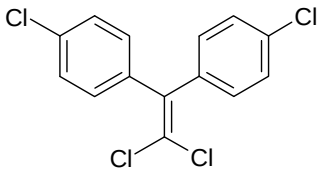




http://www.epa.gov/hudson/dad/factsheet2005.htm



scrutinyhooligans.us



where are sources?
where to remediate?

> **Approximately 10 percent of the sediment underlying the nation's surface water is sufficiently contaminated to pose potential risks to fish and to humans and wildlife who eat fish.**

US Environmental Protection Agency

Hazard Assessment "Paradigm"

& less obvious legacies

source(s)

air we breath

water we drink

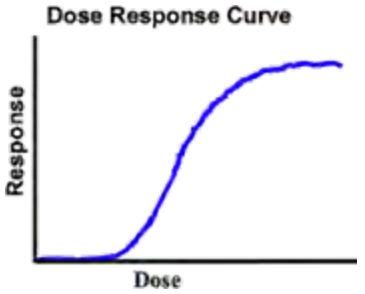
food we eat

…

not so "hard"

exposures

dose/response



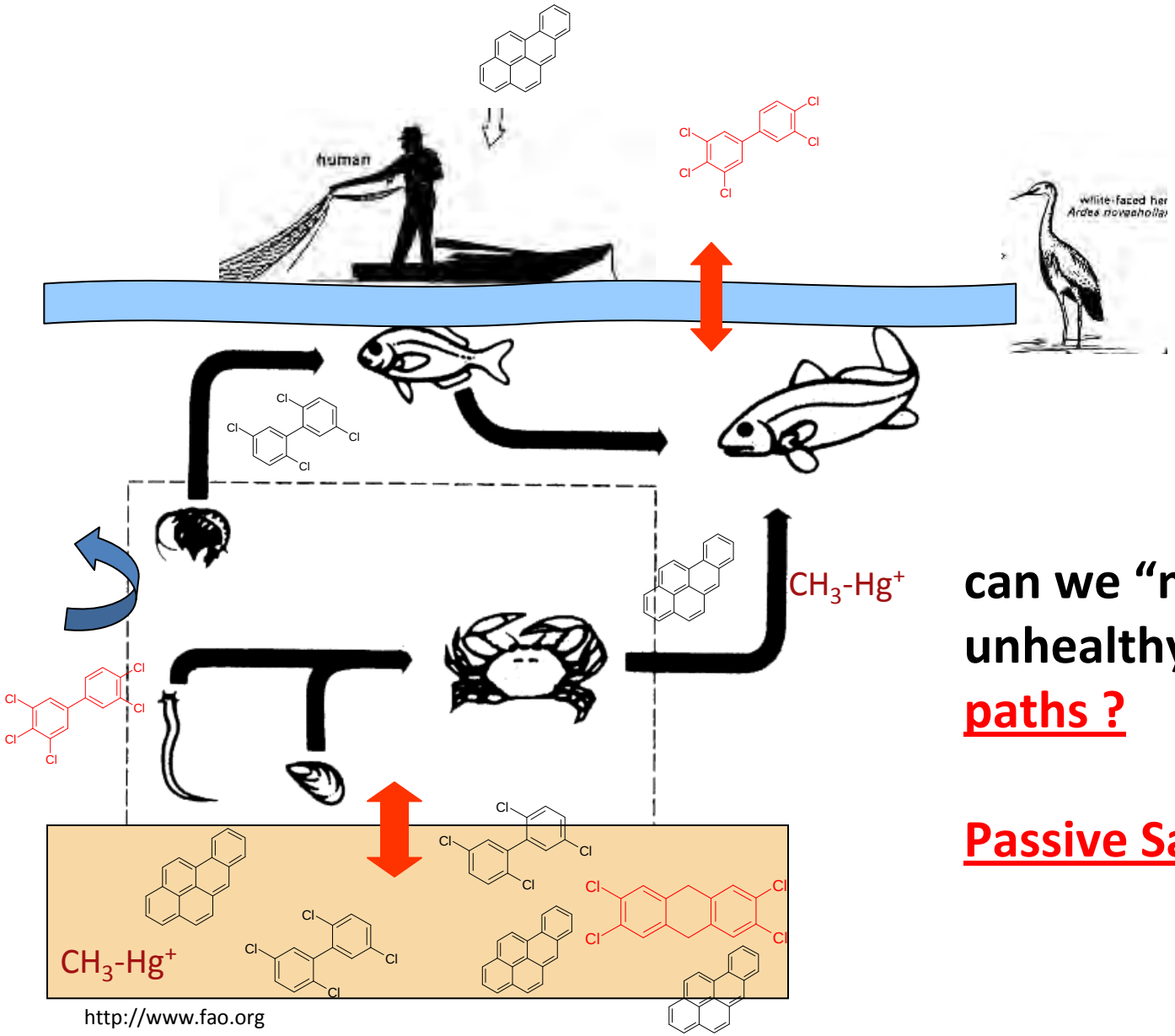
emcom.ca/science/dose.shtml

risk/hazard

(exposure)(potency) = risk of "bad" effect

=> decide if "acceptable"

Problem: how does contaminated sediment pose risks?

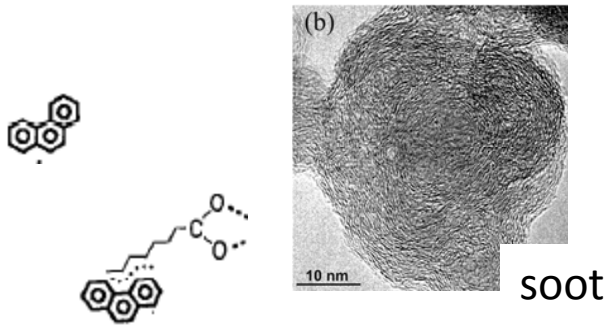


http://www.fao.org

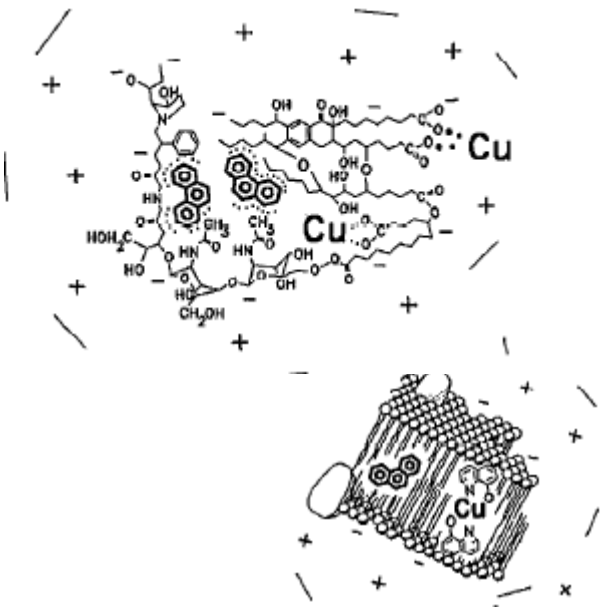
can we "map" unhealthy exposure paths ?

Passive Samplers!

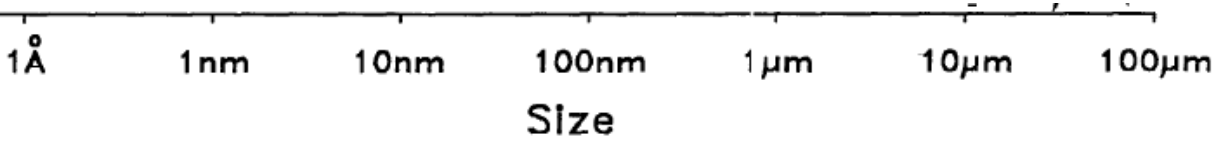
Sediments are mix of solids, colloidal suspension, and solution(s)



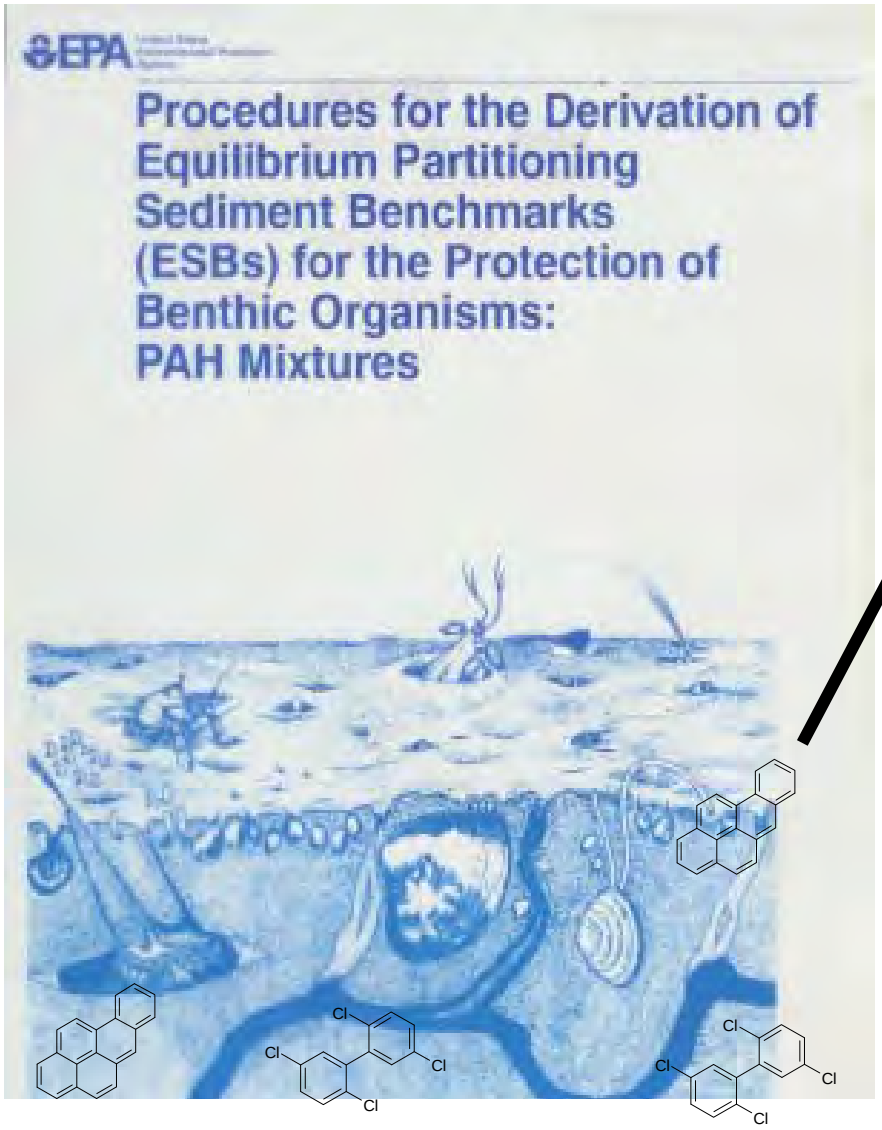
soot



char



Hunters Point (SF Bay) sediment: where are the PAHs & PCBs?



Solution? Assume contaminant in one phase: organic matter.

(basis of EPA "Benchmarks")

typically have C_{sed}, so

need $C_{sed} / f_{oc}K_{oc} = C_{pore\ water}$

if > $C_{water\ criteria}$

then bed is unacceptable,

but... is this right K_d?

or is there another way to get $C_{pore\ water}$?

Passive Samplers!

commonly find overestimated biouptake predictions (Lohmann et al 2004)

i.e., bioavailability proportional to $C_{pore\ water}$

so $C_{pore\ water} = C_{sediment}/f_{oc}K_{oc}$

observed in clam

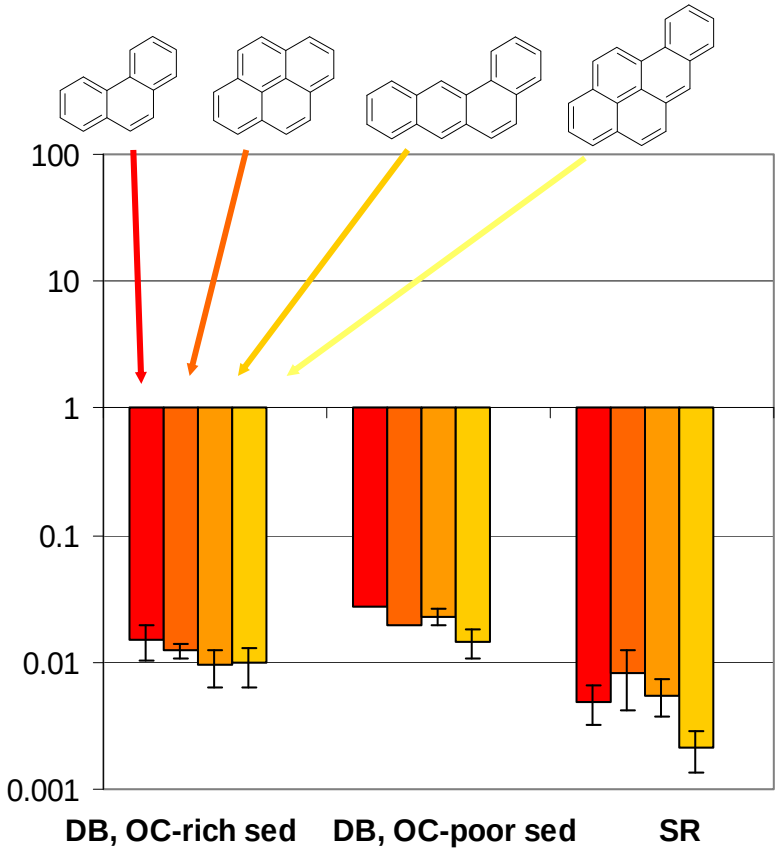
divided by

predicted in clam

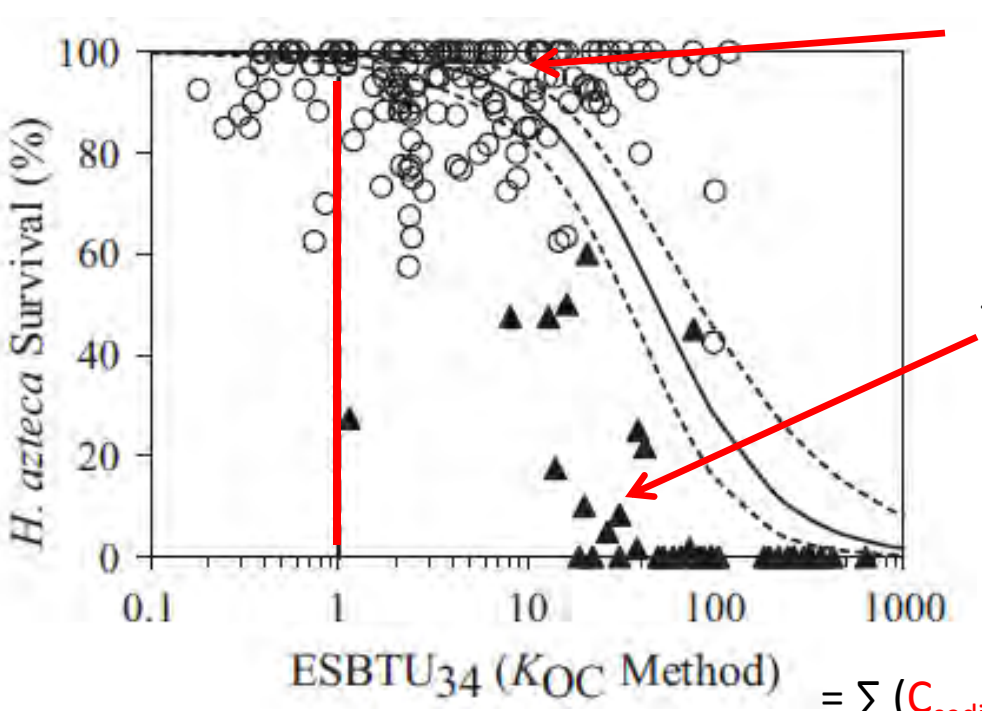
using

$C_{pore\ water}$

as above



And commonly over-estimate toxicity with measures of PAHs in sediments (McDonough et al., 2010)



nontoxic cases

toxic cases

$= \sum (C_{sediment}/f_{oc}K_{oc}) / C_{final\ chronic\ water\ concentration}$

too high if $f_{oc}K_{oc}$ too low

Approach 2: add polymeric phase to equilibrate with sediment phases

polymeric sampler inserted into multi-phase environment

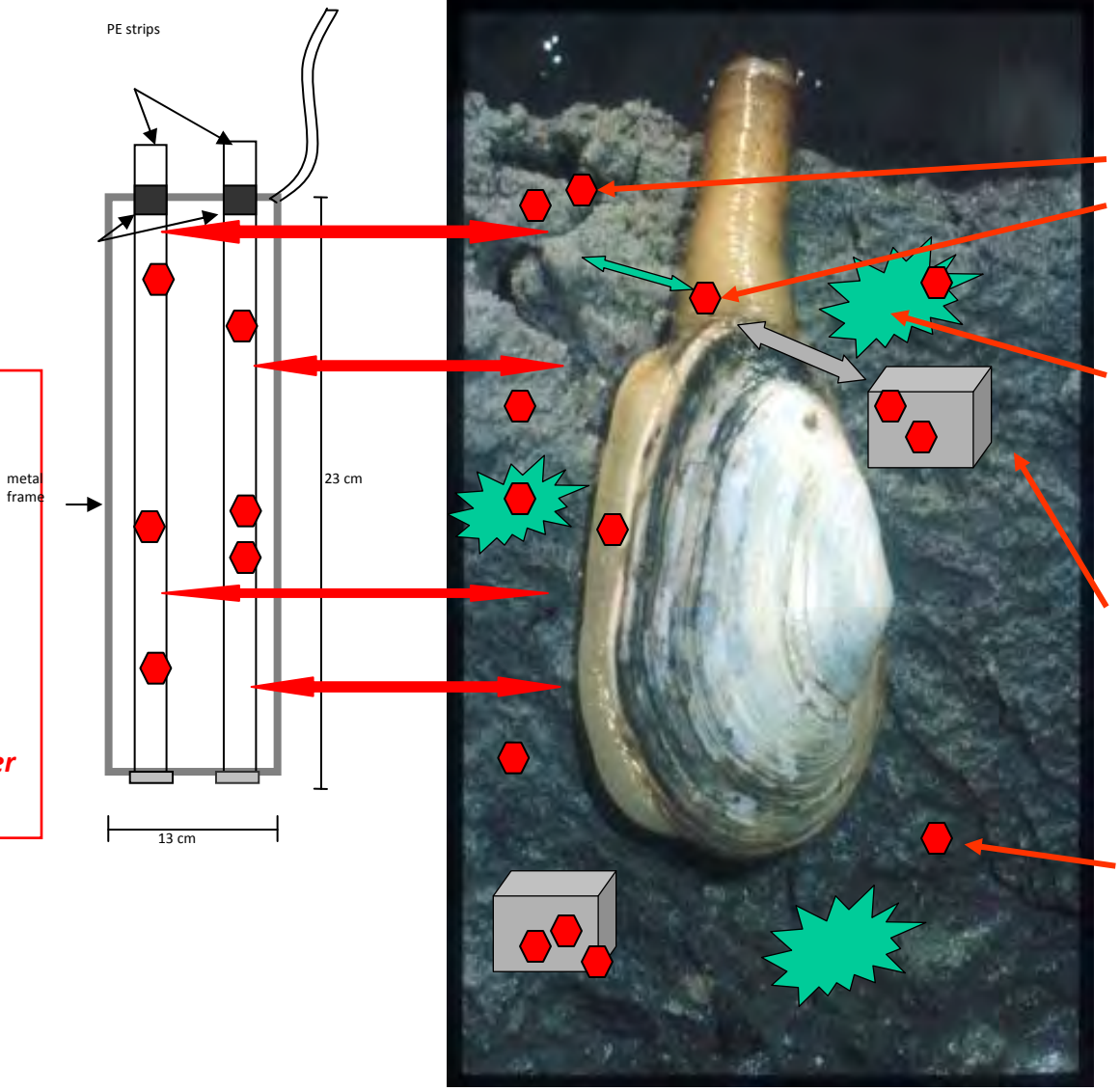
absorbs ⬢

in relation to

chemical *activity*

or

$C_{pore\ water} = C_{PE} / K_{PEwater}$



This “passive sampling” solution:

advanges

directly reveal “available” concentrations (activities)

can us in field deployments without mixing

facilitates contaminant analyses

cost-effective

historically

mussels **SPMDs** **SPME (PDMS)** **LDPE, POM, others for water & sediment**

Farrington et al. 1983 Huckins et al. 1993 Pawliszyn group 1992

Passive Sampling Approaches for Contaminated Sediment Management

FANTASTIC GROUP OF SPEAKERS!!!

1. *Phil Gschwend (MIT)*
   "Passive sampling in sediments: We can finally get the story right!

2. *Kees Booij (Royal Netherlands Institute for Sea Research)*
   "Passive sampling of nonpolar compounds in sediments"

3. *Loretta Fernandez (US EPA-Narragansett, RI)*
   "Using a diffusive mass transfer model to interpret contaminant uptake by polymeric passive samplers from environmental porous media?

4. *Keith Maruya (Southern California Coastal Water Research Project)*
   " Passive sampling devices (PSDs) to improve sediment quality assessment"

5. *Upal Ghosh (University of Maryland, Baltimore County)*
   "Application of passive samplers to monitor remediation progress"

6. *Stephen Ells (US EPA-Washington, DC)*
   "Increasing regulatory acceptance of passive samplers"

this morning's first speaker…

1. is still waiting for the Red Sox to invite him to a spring training try out!
2. fun guy…skilled athlete…brilliant scholar!
3. never shy about asking questions…
4. gives terrifying final exams(!)
5. & is generally useless in the field …

etc. etc. etc.

and today he joins us to talk about:

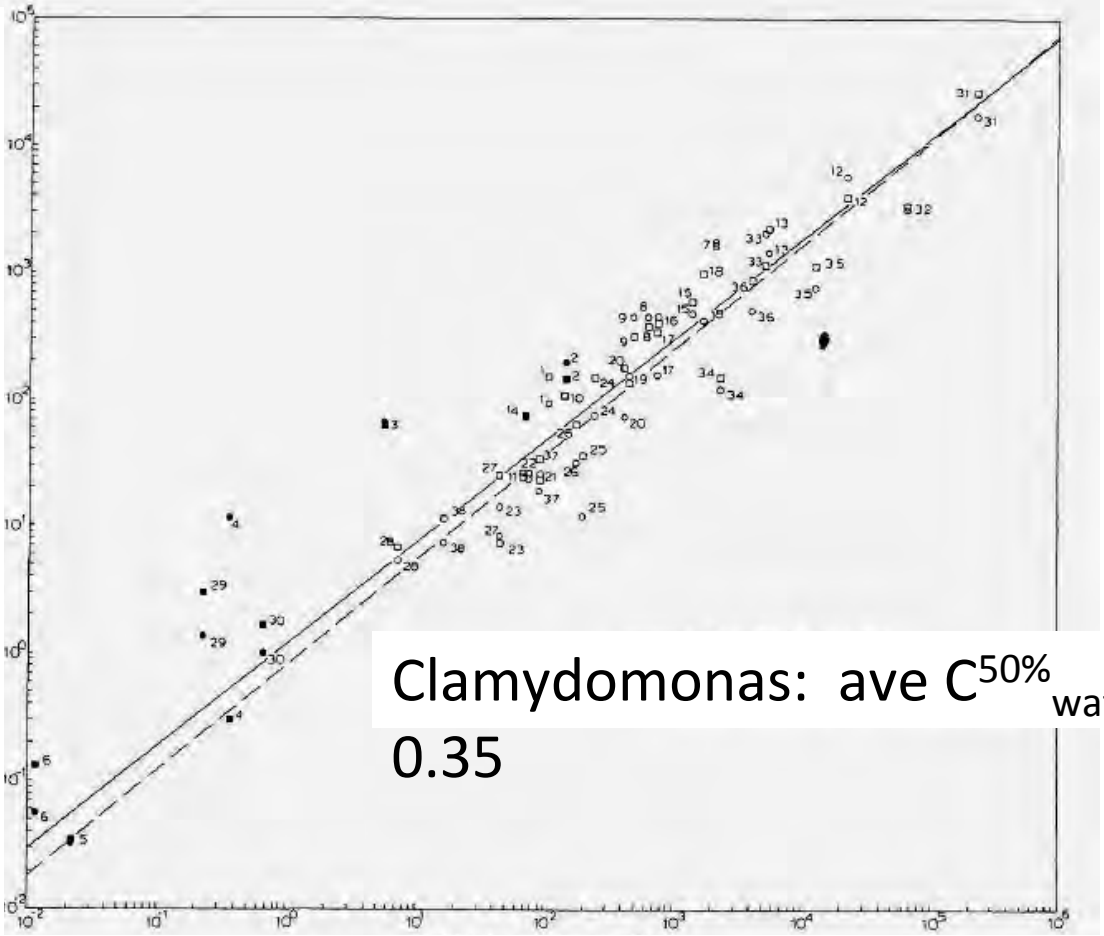
Passive sampling in sediments: We can finally get the story right!

START	END	TOPIC/TITLE	SPEAKER	ORGANIZATION
8:30 AM	8:40 AM	Welcome & Introduction by Session Chair	Philip Gschwend	Massachusetts Institute of Technology
8:40 AM	9:10 AM	KEYNOTE: Passive Sampling in Sediments: We Can Finally Get the Story Right!	Philip Gschwend	
9:10 AM	9:35 AM	Passive Sampling of Nonpolar Compounds in Sediments	Kees Booij	Royal Netherlands Institute for Sea Research
9:35 AM	10:00 AM	Using A Diffusive Mass Transfer Model to Interpret Contaminant Uptake by Polymeric Passive Samplers from Environmental Porous Media	Loretta Fernandez	U.S. Environmental Protection Agency – Office of Research and Development
10:00 AM	10:20 AM	**Break**		
10:20 AM	10:45 AM	Passive Sampling Devices (PSDs) to Improve Sediment Quality Assessment	Keith Maruya	Southern California Coastal Water Research Project
10:45 AM	11:10 AM	Application of Passive Samplers to Monitor Remediation Progress	Upal Ghosh	University of Maryland Baltimore County
11:10 AM	11:35 AM	Increasing Regulatory Acceptance of Passive Samplers	Stephen Ells	U.S. Environmental Protection Agency – Office of Superfund Remediation and Technology Innovation
11:35 AM	11:45 AM	**Discussion/Wrap-Up**	Philip Gschwend	

1. Toxicity is related to chemical activity (Hutchinson et al. 1980)

$C^{50\%}_{water}$ (uM)

water concentration that slows photosynthesis by factor of 2



Clamydomonas: ave $C^{50\%}_{water}$/Sol'y = 0.35

water solubility (uM)

Toxicity and measures of PAHs in sediments (McDonough et al., 2010)

$$\sum_{34} [PAH_{pore\ water}] / [final\ chronic\ water\ concentration]$$

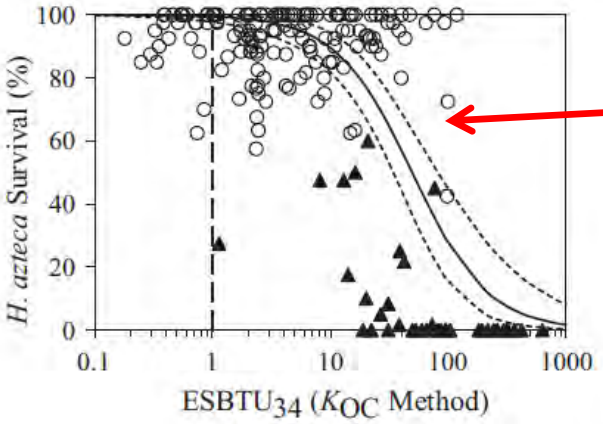
where

$[PAH_{pore\ water}] = [PAH_{sediment}] / (f_{oc}K_{oc})$

or $[PAH_{sediment}] / (f_{oc}K_{oc} + f_{BC}K_{BC}PAH_{pw}^{-0.3})$

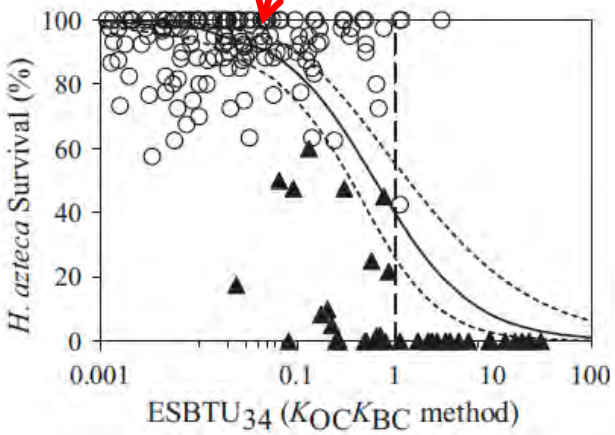
move data "left"

or use measured $[PAH_{pore\ water}]$



100% of toxic

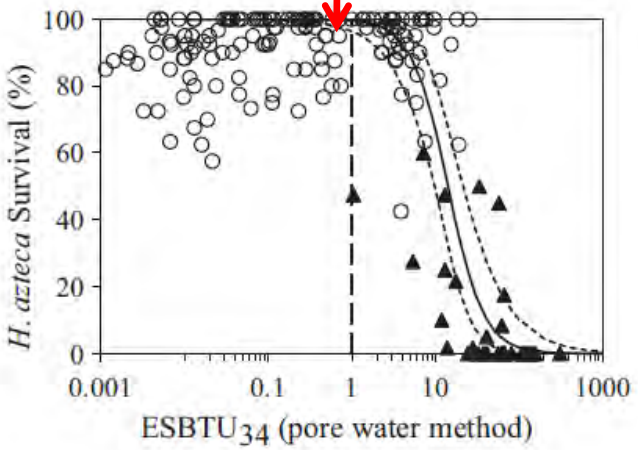
17% of nontoxic



43% of toxic

97% of nontoxic

do we have K_{BC} and n right?



100% of toxic

71% of nontoxic